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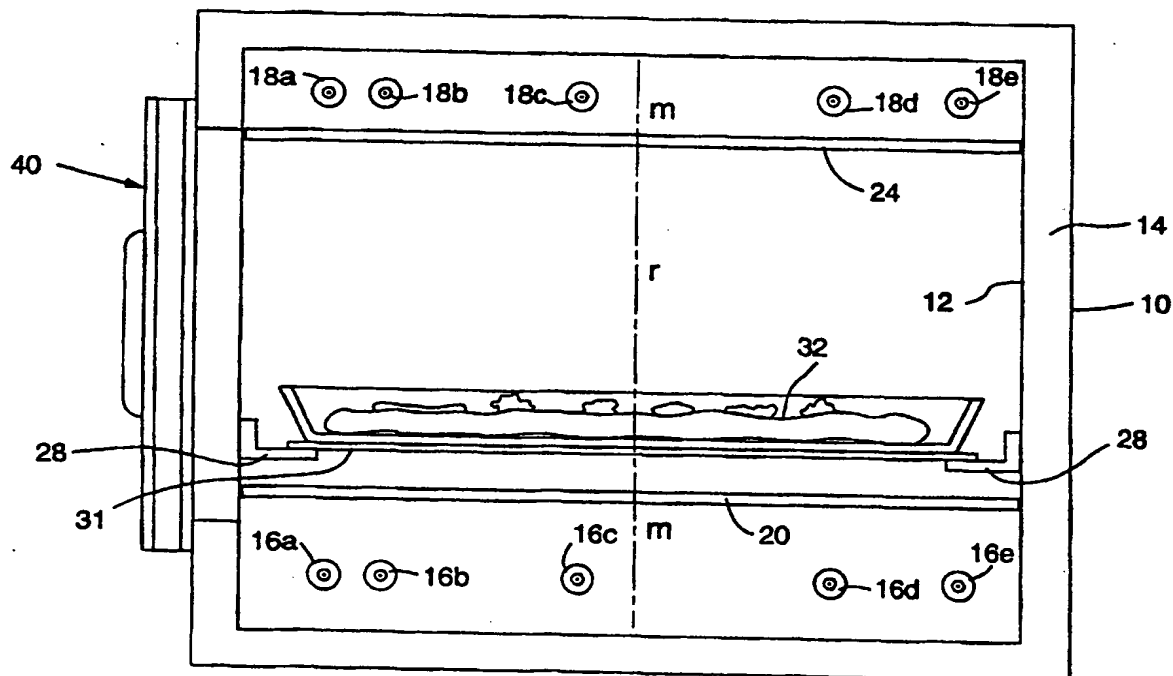
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(54) Title: APPARATUS AND METHOD FOR UNIFORMLY COOKING FOOD WITH ASYMMETRICALLY PLACED RADIANT ENERGY SOURCES



## (57) Abstract

An oven for cooking with light having wavelengths in the visible, near visible, and infra-red spectral ranges uses one or more quartz halogen tungsten lamps or quartz arc bulbs positioned above and below the food item. Uniform cooking of the food item is achieved by positioning the lamps asymmetrically with respect to the midline of the oven and by rotating the food item on a rack during the cooking cycle.

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APPARATUS AND METHOD FOR UNIFORMLY  
COOKING FOOD WITH ASYMMETRICALLY PLACED  
RADIANT ENERGY SOURCES

Related Applications

5           This application is a continuation-in-part of  
application serial No. 07/738,207, filed July 30, 1991  
which was a continuation-in-part of application serial  
No. 07/350,024, filed May 12, 1989, now U.S. Patent  
5,036,179 which was in turn a continuation-in-part of  
10          application serial No. 07/195,967, filed May 19, 1988,  
now abandoned.

Field of the Invention

          This invention relates to the field of radiant  
source ovens. More particularly, this invention  
15          relates to ovens having a rotating rack and an array of  
linear radiation sources typically shorter than the  
transverse dimension of the cooking location and which  
are arranged to maximize uniform cooking of a food  
item.

20          Background of the Invention

          Ovens following the present invention and having  
linear sources of visible and infra-red radiant energy  
are disclosed and described in U.S. Patent No.  
5,036,179 and U.S. Patent Application Serial No.  
25          07/738,207 which are incorporated herein by reference.  
These ovens provide high-speed, high-quality cooking  
and baking of food items by impinging high-intensity  
visible, near-visible, and infrared radiations onto a  
food item. The ovens cook the food items within the  
30          short periods of time normally found in microwave  
cooking while maintaining the browning of infrared  
cooking and the quality of conduction-convection  
cooking. When food is exposed to a sufficiently

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intense source of visible, near-visible, and infrared radiation, the food absorbs low levels of visible and near-visible radiation, thereby allowing the energy to penetrate the foodstuff and heat it deeply. The longer infrared radiation does not penetrate deeply but acts as an effective browning agent.

Ordinarily, the source of the visible, near-visible and infrared radiation for this invention is in excess of two elongated quartz-halogen tungsten lamps, or equivalent means such as quartz arc lamps. Typical quartz-halogen lamps of this type operate at 3000 degrees Kelvin and convert electrical energy into black body radiation having a range of wavelengths from .4  $\mu\text{m}$  to 4.5  $\mu\text{m}$  with a peak intensity at .965  $\mu\text{m}$ . Each lamp can generally provide about between 1.5 and 2 kW of radiant energy with a significant portion of the energy in the visible light spectrum.

The ovens can use a plurality of these lamps or an array of several lamps either operated in unison or selectively operated in varying combinations as necessary for the particular food item sought to be cooked. These radiation sources are ordinarily positioned above and below the food item. The walls of the surrounding food chamber are preferably made from highly reflective surfaces. The visible and infrared waves from the radiation sources impinge directly on the food item and are also reflected off the reflected surfaces and onto the food item from many angles. This reflecting action improves uniformity of cooking.

The intensity of radiant energy received by an object decreases with the increase in distance between the object and the radiant energy source. Despite the improved uniformity of cooking provided by the reflective interior surfaces of the oven, the areas of the food item that are positioned directly above or

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below the radiation sources receive more direct energy and therefore cook more quickly than their surrounding areas.

5        Figures 1A and 1B show an end view and a longitudinal side view, respectively, of a single linear radiation source 100 and further show the distributions of light intensity measured at the surface of a food item positioned underneath the radiation source. As shown in both figures, the  
10        regions of the food item which are positioned directly below the light source are exposed to the maximum intensity received by the food item, while the surrounding areas are exposed to significantly lower intensities.

15        Figure 2A shows a lamp configuration under which a food item 104 is cooked under an array of elongate radiation sources 100 that are shorter than the length of the food item and that are arranged in parallel. The food item is cooked to the desired degree in the  
20        regions of the food item that are close to the lamps, designated by shading in Figure 2B. The unshaded regions remain uncooked or undercooked.

     Rotating the food item relative to the stationary radiation sources also yields a non-uniformly cooked  
25        end product. Figure 3A shows a circular food surface 104, such as a pizza, positioned underneath a single radiation source 100a having a length  $l$ . The radiation source is parallel to and shorter than diameter  $d$  of the pizza. Referring to Figure 3B, when the pizza is  
30        rotated about its center  $C$ , the radiation source cooks a circular region AA having diameter equal to the length  $l$  of the radiation source 100a. Moreover, cooked portion AA is itself non-uniformly cooked: the regions that are closer to the center  $C$  spend more time  
35        under the radiation source and therefore are cooked

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more thoroughly than those regions that are further away from it.

As shown in Figures 4A and 4B, positioning a single source 100b parallel to a diameter d of the rotating pizza will cook only an annular path BB, leaving the remainder of the pizza uncooked.

Combining the concepts described with respect to Figures 3B and 4B partially solves the problem of non-uniform cooking. Figure 5A shows five equally spaced radiation sources 100c, 100d, 100e fixed over a pizza 104 which is positioned on a rotating rack (not shown). The sources are equal in length, and their length l is less than the diameter d of the pizza 104. The center source 100c lies above the diameter of the pizza, and the outer radiation sources are positioned parallel to it.

When the pizza is rotated about the center C, the energy generated by radiation sources 100d and 100e creates partially cooked annular paths similar to region BB in Figure 4B. These paths are also exposed by the center source 100c, although their exposure time is minimal as explained with respect to Figure 3B.

Designing an oven having radiation sources that extend beyond the outer boundaries of the food location in the oven would allow uniform cooking of the food region even where the sources are arranged as in Figure 5A. However, there are limits to the size of radiation sources that can be manufactured for use in ovens of the present type, making it often impractical to utilize radiation sources that are longer than the area of food sought to be cooked. To attempt to do so would unnecessarily limit the size of the food items which could be cooked using combined visible and infra-red radiation. A lamp configuration is therefore needed that will provide uniform cooking even where the size

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of the cooking surface exceeds the dimensions of the lamps.

#### Summary of the Invention

5       The present invention utilizes an array of light  
sources asymmetrically placed with respect to the  
diameter of a rotating rack. The lamps have a length  
that is shorter than the width or diameter of a cooking  
area. Rotation of a food item beneath the  
10       asymmetrically placed lamps causes substantially all of  
the food surface to be exposed to substantially the  
same radiation for a substantially equal period of time  
and therefore results in substantially uniform cooking  
of the food item.

#### Description of the Drawings

15       Figures 1A and 1B are an end view and a side view,  
respectively, of a lamp and with its associated  
intensity distribution measured at the surface of a  
food item positioned underneath the lamp.

20       Figures 2A through 5B are schematic  
representations showing four different lamp arrays and  
the regions of a food item that are cooked by each of  
the respective arrays.

Figure 6 is a front section view of an oven  
according to the present invention.

25       Figure 7 is a side section view of a preferred  
embodiment of an oven according to the present  
invention.

30       Figures 8A, 8B, and 8C are a perspective view, a  
top plan view, and a side elevational view,  
respectively, showing the preferred means for rotating  
the rack of the present invention.

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Figure 9 is a schematic representation of the preferred lamp configuration according to the present invention.

#### Detailed Description of the Invention

5           The present invention is comprised generally of an oven 10, a rotating circular rack 31, and upper and lower arrays 18, 16 of radiant energy sources, or lamps.

10           Figure 6 is a front section view of the oven. The energy for cooking is supplied by lower heating lamps 16 and upper radiation heating lamps 18. The lamps are preferably quartz-halogen tungsten lamps which are capable of producing approximately 2 kW of radiant energy with a significant portion of the light energy  
15           in the visible light spectrum. When illuminated, the lighted portion of a preferred lamp has a length of approximately 10 inches.

          The inner surface of the inner wall 12 is preferably a highly polished metal, such as aluminum or  
20           stainless steel, which is very reflective to the wide spectrum of wavelengths from the radiant lamps. The oven has a door 40 (Figure 7) which also has a reflective inner surface.

          Two radiation transparent plates 20 and 24 are  
25           used to isolate the cooking chamber from the radiant lamps, making the oven easier to clean. These plates can be formed from materials, such as high quality heat-resistant glasses and ceramics that are transparent to visible, non-visible and infrared  
30           radiations. The lower transparent plate 20 is supported by brackets 22a and 22b and is positioned above the lower lamps 16. The upper transparent plate 24 is supported by brackets 26a and 26b and is positioned below upper lamps 18.



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Shelf 28 is mounted between the transparent plates inside the oven chamber. As shown in Figure 8A, the shelf 28 has a circular cut out portion 27 which is lined at its perimeter by a track 29. A circular rack 31, comprised of a grid of small diameter metallic bars 33, rests loosely on the track 29 as shown in Figure 8B. During use, a heat-resistant glass dish which holds the food is placed on top of the rack for cooking. The rack has a diameter of preferably 12 to 14 inches and is capable of rotating around an axis of rotation, designated r. Rollers 35 are positioned such that when one of them is rotated by a motor (not shown), they engage with the perimeter portion of the rack, causing the rack to rotate within the track 29.

Figure 7 shows a side section of the preferred oven according to the present invention. In the preferred embodiment, there are 5 lower lamps 16a through 16e and 5 upper lamps 18a through 18e. By appropriately selecting the lateral spacing between the lamps relative to the food, even cooking can be achieved over the entire surface. This is accomplished by rotating the food item using the rack 31 and by arranging the lamps such that during the cooking cycle all regions of the food surface receive equivalent amounts of energy from the lamps. As described above, this requires arranging the lamps such that all regions of the food surface are positioned directly underneath a lamp for substantially equivalent periods of time.

This desired result is most readily accomplished by positioning the lamps asymmetrically with respect to the midline m of the lamp array. Asymmetry is achieved by positioning unequal numbers of lamps on either side of the midline, and/or by positioning the lamps at unequal distances from the midline such that the lamp

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arrangements on either side of the midline are not "mirror images" of one another.

Alternatively, an equal number of equally spaced lamps may be positioned on either side of the midline, and asymmetrical configurations of lamps may be selectively illuminated depending on the size and of the food item sought to be cooked and its ability to absorb visible light. Because different food types will be capable of absorbing different amounts of energy, a configuration of this type would be particularly helpful when, for example, a dish containing various foods is positioned on the rack for cooking.

A top view of the preferred lamp array is shown in Figure 9. In the preferred oven, the lamps in the upper and lower arrays are identically arranged. Positioning of the lamps will be described with respect to a midline *m* which bisects the array and which intersects the axis of rotation *r* (Figures 6 and 7) of the rack 31. Three of the lamps, 18a, 18b, and 18c, are positioned on one side of the midline and are respectively 5.5 inches, 4.5 inches and 1 inch from the midline. The remaining two lamps, 18d, 18e, are positioned on the opposite side of the midline and are positioned 3.5 inches and 5.9 inches from the midline, respectively. The lamps are positioned approximately 3 inches above the rack 31. The lateral positions of the lamps from the midline can be varied plus or minus one-eighth inch from their stated positions while still maintaining substantially uniform radiation across the food location.

In the embodiment of Figure 7 the positions of the lower lamps 16a-16e are the same as the upper lamps 18a-18e but obviously the position of one of these two sets can be reversed with respect to the other.

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5 To use the oven of the present invention, the food item sought to be cooked is positioned on the rack 31 and the door 40 is closed. The motor is switched on, causing the roller to engage and rotate the rack. The lamps are illuminated for a predetermined cooking time, causing the food item to cook uniformly.

The present invention is described in relation to the preferred embodiment but is limited only in terms of the language of the appended claims.

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I claim:

1. An oven for cooking a food item having a first surface and a second surface on an opposite side of the food item from the first surface in a food location having a midline, the oven comprising:

a radiation source for directing radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum onto the food location, the radiation source comprising an array of elongate lamps positioned in spaced parallel relationship above the first surface of the food item, each lamp being located a distance from the midline such that the distance between each lamp and the midline is different from the distances between the midline and the other lamps; and rotation means for rotating the food location about an axis of rotation intersecting the midline.

2. The oven of claim 1 wherein the radiation source further comprises a second array of lamps positioned in spaced parallel relationship below the second surface of the food item, each lamp being located a distance from the midline such that the distance between each lamp and the midline is different from the distances between the midline and the other lamps.

3. An oven for cooking a food item having a first surface and a second surface on an opposite side of the food item from the first surface in a food location having a midline, the oven comprising:

a radiation source for directing radiant energy having a significant portion of the radiant energy in the visible light range of the

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electromagnetic spectrum onto the food location, the radiation source comprising:

a first array of lamps positioned in spaced parallel relationship above the first surface of the food item on a first side of the midline, and

a second array of lamps positioned in spaced parallel relationship above the first surface of the food item on a second side of the midline, wherein the first array includes at least one more lamp than the second array.

4. The oven of claim 3 wherein the radiation source further comprises a third array of lamps positioned in spaced parallel relationship below the second surface of the food item on the first side of the midline, and a fourth array of lamps positioned in spaced parallel relationship below the second surface of the food item on the second side of the midline, wherein the third array includes at least one more lamp than the fourth array.

5. The oven of claim 3 wherein the radiation source further comprises a third array of lamps positioned in spaced parallel relationship below the second surface of the food item on the first side of the midline, and a fourth array of lamps positioned in spaced parallel relationship below the second surface of the food item on the second side of the midline, wherein the fourth array includes at least one more lamp than the third array.

6. The oven of claims 1 or 3 wherein the widest dimension of the food location is greater than the length of the lamps.

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7. An oven for cooking a food item having a first surface and a second surface on an opposite side of the food item from the first surface in a circular food location having a midline and a diameter of length  $d$ , the oven comprising:

a radiation source for directing radiant energy having a significant portion of the energy in the visible light range of the electromagnetic spectrum onto the food location, the radiation source comprising an array of elongate lamps positioned in spaced parallel relationship above a first surface of the food item, each lamp having a length  $L$  substantially equal to  $10/12d$ , the array comprising:

a first lamp positioned a distance substantially equal to  $1/10L$  from the midline,  
a second lamp positioned a distance substantially equal to  $4.5/10L$  from the midline,  
a third lamp positioned a distance substantially equal to  $5.5/10L$  from the midline,  
a fourth lamp positioned a distance substantially equal to  $3.5L$  from the midline,  
a fifth lamp positioned a distance substantially equal to  $5.9/10L$  from the midline,  
said first, second and third lamps being located on one side of the midline and said fourth and fifth lamps being located on the side of the midline

rotation means for rotating the food location about an axis of rotation intersecting the midline.

8. A method of cooking a food item in a food location having an axis of rotation and a midline intersecting the axis of rotation, the food item having a first surface and a second surface on an opposite

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side of the food item from the first surface, the method comprising the steps of:

5 directing radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum onto the food location;

10 initiating said radiant energy from a plurality of spaced apart substantially parallel tubes above at least one of said surfaces and spaced different distances from said midline; and

rotating the food location about the axis of rotation.

9. A method of cooking a food item in a food location having an axis of rotation and a midline  
15 intersecting the axis of rotation, the food item having a first surface and a second surface on an opposite side of the food item from the first surface, the method comprising the steps of:

20 directing radiant energy having a significant portion of the radiant energy in the visible light range of the electromagnetic spectrum onto the food location;

25 initiating a first portion of said radiant energy from a first array of a number N of spaced apart substantially parallel tubes positioned on a first side of said midline above at least one of said surfaces;

30 initiating a second portion of said radiant energy from a second array of a number more than N of spaced apart substantially parallel tubes positioned on a second side of said midline above at least one of said surfaces; and

rotating the food location about the axis of rotation.

Q 100

FIG. 1A



FIG. 1B

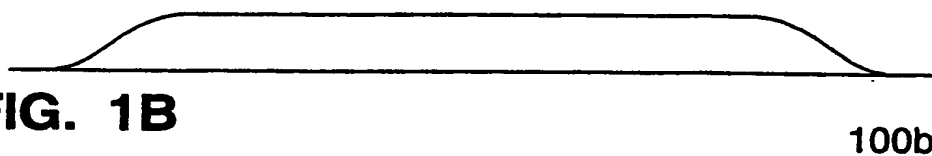


FIG. 2A

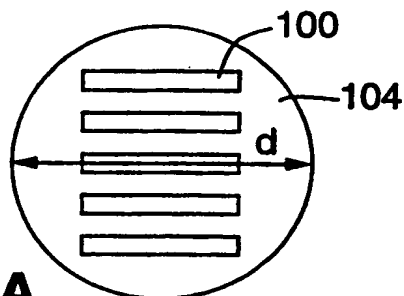


FIG. 2B

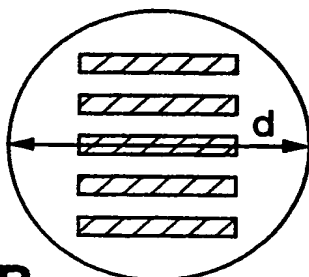


FIG. 3A

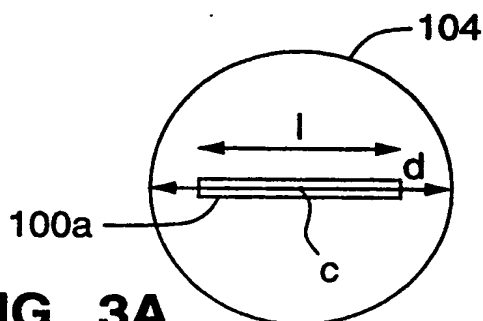


FIG. 3B

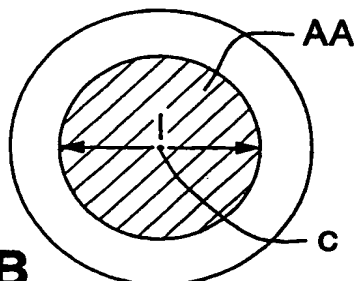


FIG. 4A

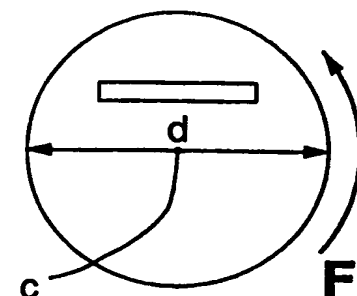


FIG. 4B

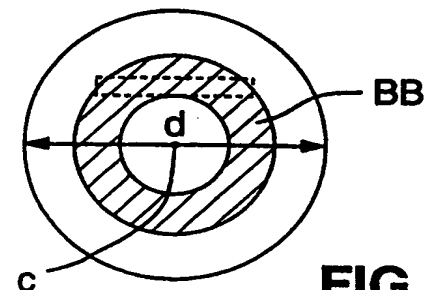


FIG. 5A

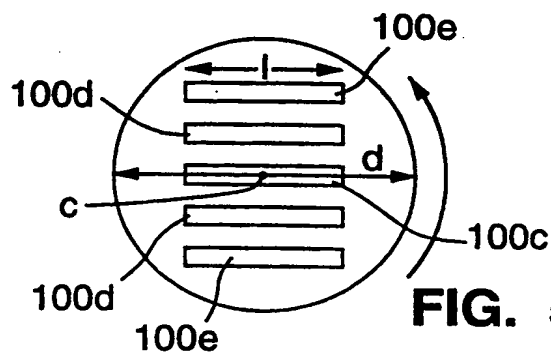
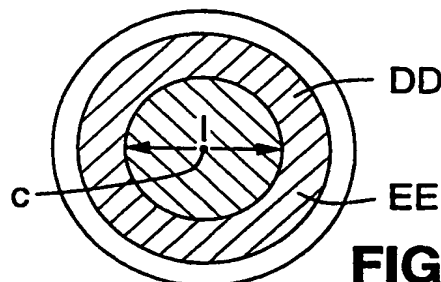


FIG. 5B





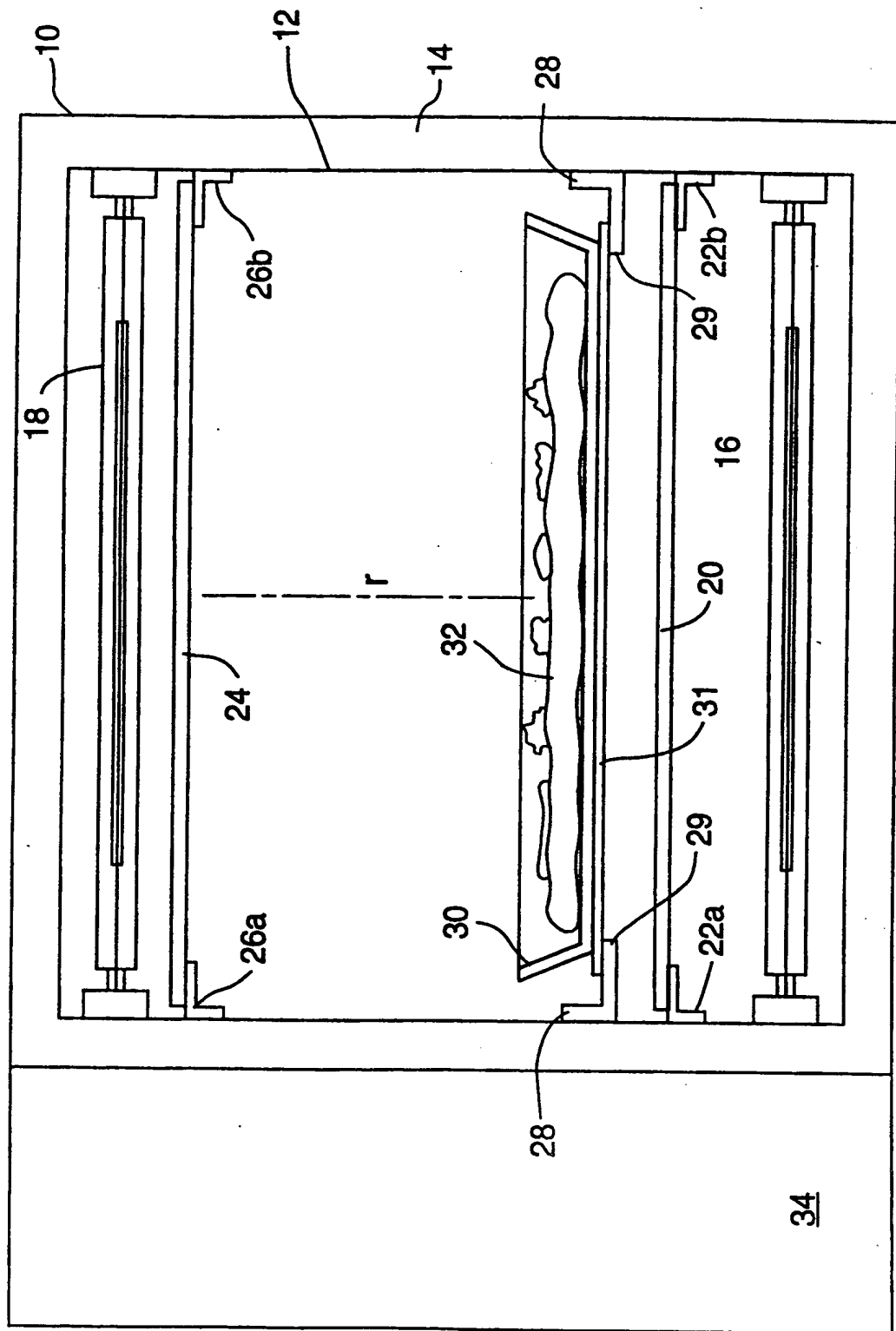


FIG. 6

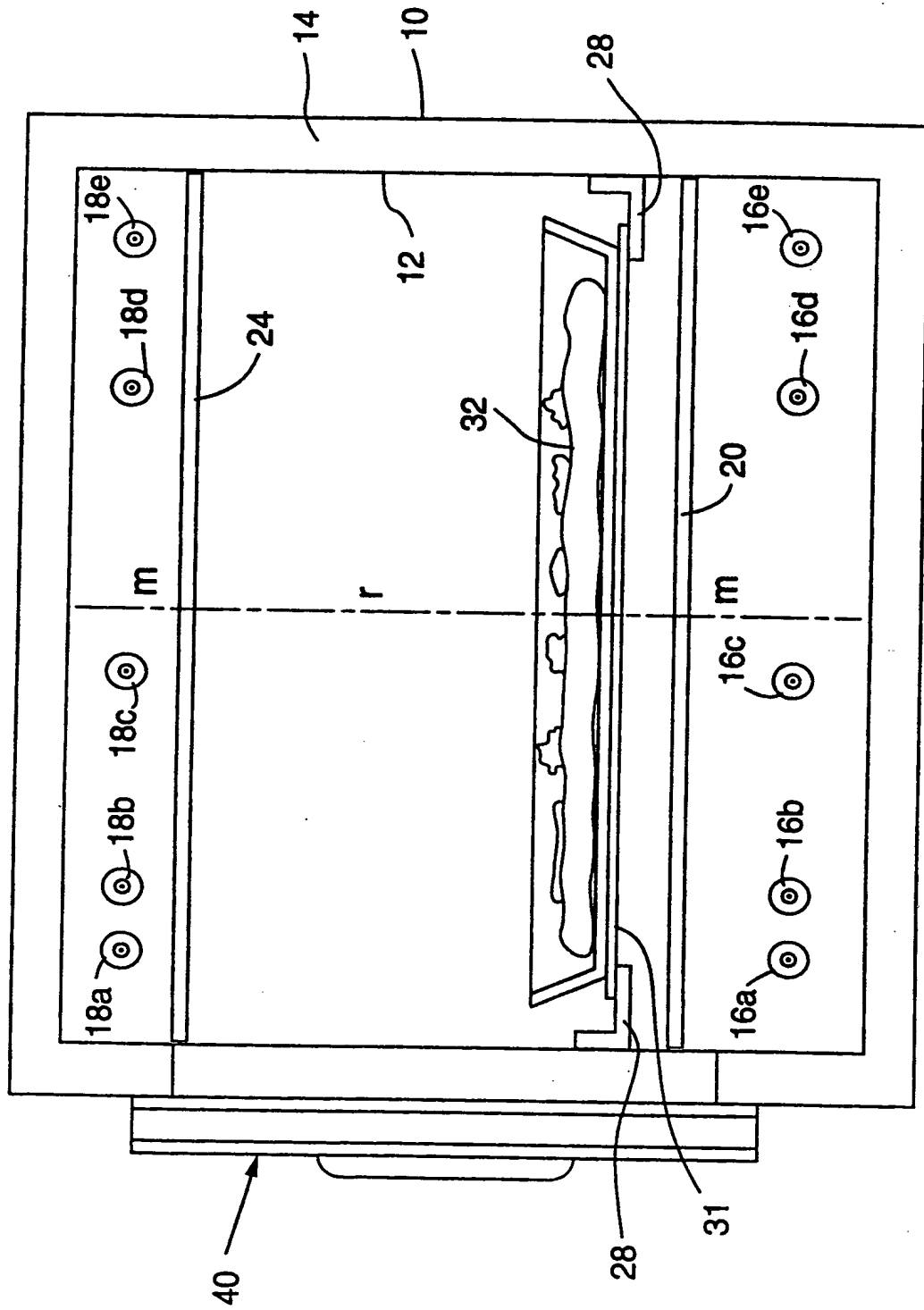
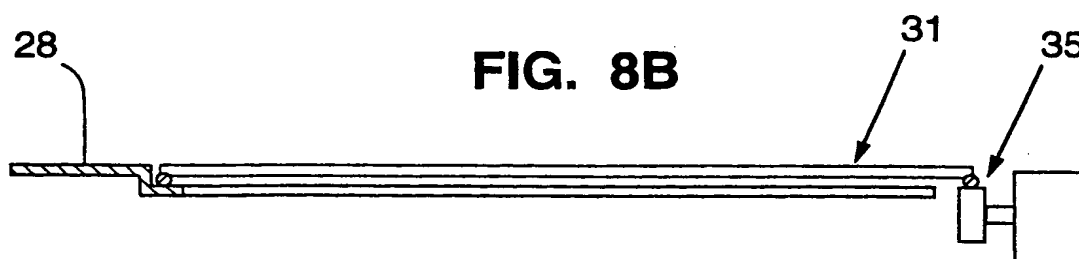
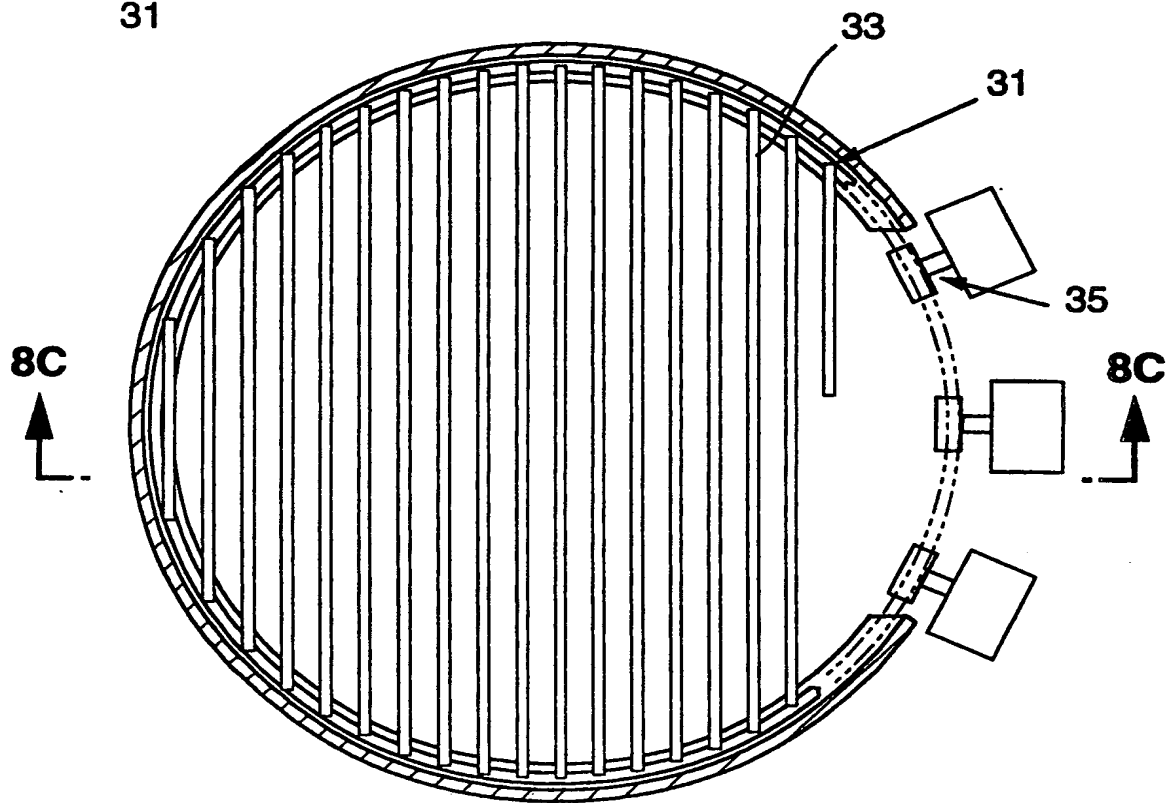
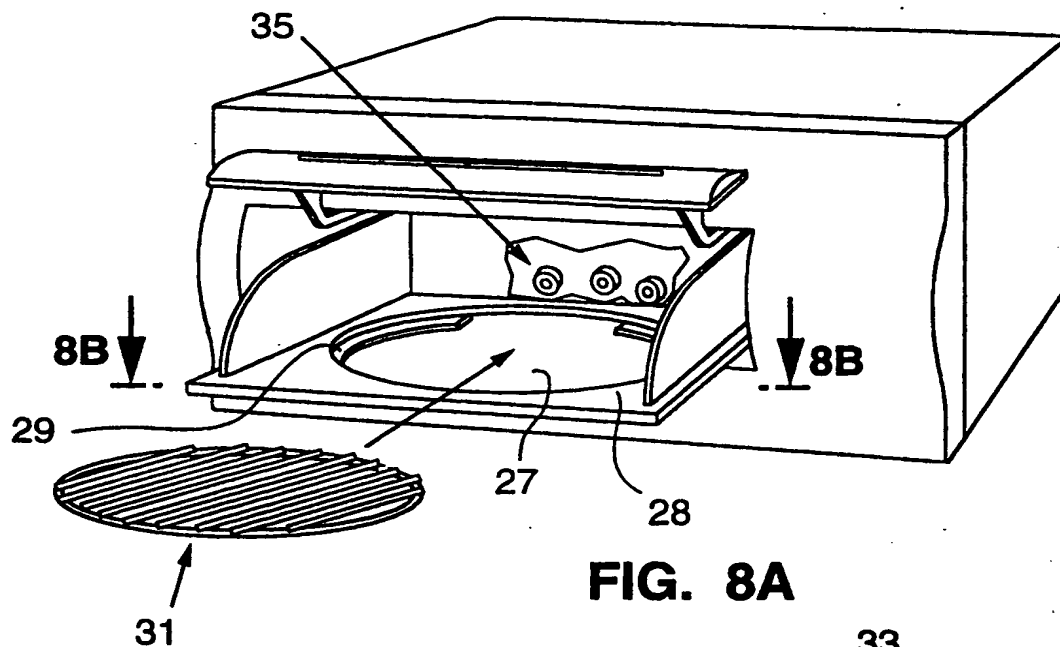
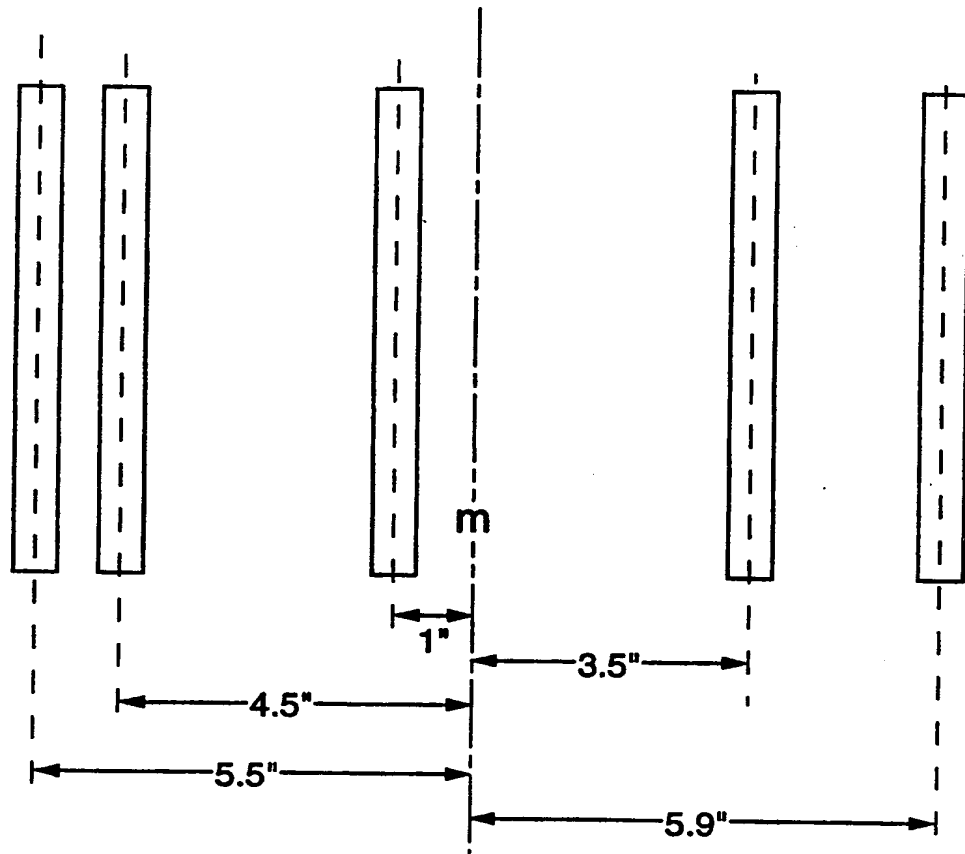


FIG. 7

SUBSTITUTE SHEET



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**FIG. 9**

SUBSTITUTE SHEET

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 5 H05B3/00 H05B3/44 A47J37/06

According to International Patent Classification (IPC) or to both national classification and IPC

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP,A,0 226 407 (THORN EMI PATENTS LTD.) 24 June 1987 ---	
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